Point-source Database Theory and Its Application in Database Architecture Design of Digital Mine

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1. Abstract

Mining belongs to resources industry and geological exploration acts a fundamental role in its subsistence. The information system in mining enterprise consists of three types: data-oriented system, such as geological point-source information system; process-oriented system, such as enterprise management information system; and finance-oriented system, such as enterprise financial information system. As a reflection to the important role of geological exploration, the geodata-oriented information system is the basis for informatization in mining enterprise. In big mining corporation which manages more than one mine, the geological information system construction frequently faces several problems: 1) pursuing the efficient functions in short time and ignoring the data management; 2) as a result, without clear data basis which satisfies the multi-subject application; 3) the information islands caused by the independent systems in different subcorporations or departments. These infract the basic rule of information engineering which takes data management as the core of information system. The point-source database theory may supply a scheme in the database structure design. Its meaning includes two parts: the "point" indicates that it is the minitype workstation for basic survey and exploration units and "source" indicates that it is also a node in geological and mineral information network within the corporation. The key principle of the theory is taking data management as the core of data integration. The guarantee for successful application is the standardization of terms, codes, legends and procedures in execution. With the point-source theory, the realized subject database bands the current data models and future data models together. The inherent attributes of data and the classification system ensure the correct structure, while the attributes classification system is also independent from the data application modes. The functions of data analysis and data processing in the information system renovates quickly. But the primary data types and data structures can satisfy them a long time with little emendation.

2. Introduction

Mining is a conventional industry in the national economy of China. As we what can see from the situation in recent years, the mining industry is on the way to new industrialized era, which should widely applied the advanced information technologies and efficiently improve the production efficiency and management level within the whole industry, and realize the great-leap-forward development. The informatization in mineral exploration and mining industry of China has achieved great improvements in recent years, nevertheless, we also face many objective difficulties and there is still a long way to go. With the development of information technology, network technology and automation technology, the informatization is developing towards the directions of integration, intelligentization and multi-functional. From the actual situation of the industry we can see that Digital Mine should be the objective and direction of informatization of mining industry. The tasks of Digital Mine primarily come to be the data warehouse of information in the industry, then with the technologies in spatial analysis, data mining, visual reality, visualization, network, multimedia and scientific calculation, to supply new technological platform and tools for the simulation, emulation and processes analysis in mineral resources evaluation, mining plan and design, exploitation design, security in production and decision-making.

Data is the operating object of various information systems in the mine. Its existing and moving ways decide the life and energy of the system. The term Digital Mine delivers the people's hope to the informatization of work in mining industry. International conferences in this field of research, such as International Geological Congress (IGC), annual conferences of International Association for Mathematical Geology (IAMG), Computer Applications in the Minerals Industries (APCOM), annual meetings of the Society for Mining, Metallurgy, and Explorations Inc. (SME), have greatly promoted the academic study in this field. In M. Scoble's description, the Digital Mine will provide the information infrastructure to serve as the foundation for minewide automation (M. Scoble, 1995). The information system in the mining corporation consists of three systems: the data-oriented system (geological point-source information system), process-oriented system (enterprise management information system) and finance-oriented system (enterprise financial information system). As the mineral resources are the basis for the existence of mining enterprise, the data-oriented geological and mineral point-source information system is the basis for enterprise management system, resource plan system and decision-making system. The geological and mineral data integration (Dessureault, 2003; Dessureault, et al, 2004) and development of geological and mineral point-source information system should be put in the prior place in Digital Mine.

3. The Meaning of Point-source Database

The point-source database theory may supply a scheme in the database structure design. Its meaning includes two parts: the "point" indicates that it is the minitype workstation for basic survey and exploration units and "source" indicates that it is also a node in geological and mineral information network within the corporation. We can explore the place of point-source database from the structure of point-source information system. Geological and mineral resources point-source information system (Wu, 1998; Wu, et al., 2002) integrates the data collection, data management, data analysis, spatial data processing, map editing and resources prediction and assessment in a whole system, which roots in the local exploration organizations (data collection sites). The point-source information system will realize the informatization of data collection and processing in the entire process of geological and mineral exploration, as well as the informatization and network of data management and searching, and combine the two objectives together. It is a node with complete information in the network, and a workstation with complete functions in the site. Geological and mineral point-source information system is a cascading composite structure, which consists of three parts: data management, data processing and resources prediction and assessment, with subject point-source database as the core of the system. The system design should obey the principle of structural-functional consistency, which means all kinds of data processing applications should focus on database to set out their work. The point-source information system aims at realizing the informatization of the entire flow of field data collection, data storage, management, analysis, map editing, and the resources prediction and assessment. The system should be provided with uniform data mode, standards and terminology classification codes system, standardized data processing ways and integrated functional applications. It's also an open developing platform, which not only supplies interfaces to join with the latest fruits in software, but also supports users to carry out complementary redevelopments according to their specific requirements. The intending direction for the point-source information system is the conjunction of five repositories (attribute database, spatial database, model database, method database and knowledge database) and integration of multi-S (DBS, CADS, GIS, RS, GPS and ES).

4. Basic Elements to Support the Point-source Database

The geoscientific knowledge system based on standards comes to be the basis for subject point-source database, and also the guarantee for the benefits of the network jointed by the local cites. Geological and mineral ontology is the explicit definition of the various concepts inside the field of geology and mine (Fig. 1). It's authoritative in this community and cannot be modified discretionarily. After proper packaging, the ontology can be referenced directly, thus solve the problems in cross-operation and reusing of classification codes. One distinct feature of information ontology is the relationships among classes. It regulates the methods and restrictions for the definition and application of relationships (He, et al., 2003). Ontology reflects the current knowledge in the field of geology and mine. It's the real reappearance of the real world. Meanwhile, the ontology is evolving with the update of the knowledge. It solves the problems existing in the foundation of dynamic relationships of classification codes system and the real-time update of specific knowledge. Point-source database is the core of point-source information system, therefore, besides the application of standards to realize the features of point-source database, we also need to consider quite a few other factors to improve the point-source information system as a whole.

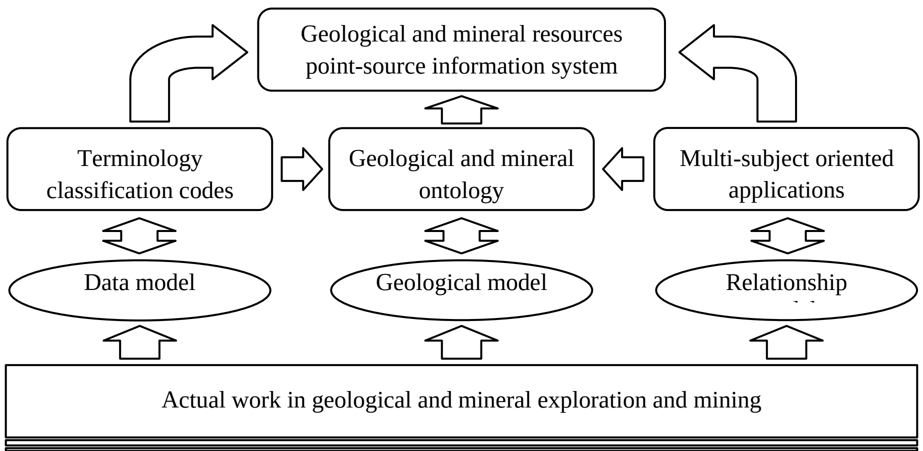

Fig. 1. The approach from real world to computer recognized models and structures.

(1) The design of point-source information system should be based on the principle of structural-functional consistency, and come to be an integrated technological system with point-source database as the core. The configuration of the system is a cascading composite structure.
(2) System analysis is the basis for system design, which should be listed out as a principle, the design of point-source database should combine the bidirectional two ways: setting up geological model, data model and concept model from the bottom to the top, then decomposing entity sets and attributes and setting up data mode from top to the bottom (Fig. 1).
(3) Developing and disposing feasible functional applications surrounding the subject database. The emphasis is not the optimization of one or two applications, but the optimization of the whole system, which makes it an integrated technological system supporting the field data collection, data storage and management, data analysis, map editing, and resources prediction and assessment.
(4) To realize the dual capabilities of data sharing and software sharing, the system should adopt the uniform data models, standard codes system, normalized map schema and legend, promissory processing methods and universal software interfaces set down by industries or governments, and put emphasis on friendly user interface development, as well as the integrated and commercial packaging of the system.
(5) Taking full consideration of the joint of geological and mineral resources an exploration and computer technology, applying the latest fundamental software and application to improve the function. Making the software to be the platform for redevelopment, and support user to carry out ameliorations to the system. In suitable situation, the functions can be transformed to new fundamental software platform.
(6) The latest fruits of research in geographic information science should be used for reference, that is, as what mentioned in above words, the conjunction of five repositories and integration of multi-S.

5. Database Configuration in the Digital Mine

Point-source database is the core of the entire system. It's the data supplier to other subsystems and also the data accepter and manager of results. The database management subsystem consists of some fundamental functions: configuration of database, import of attribute and spatial data, security policy and user management, backup and resuming of database, monitor of data sheets, transmitting and output of data. Those consist of the following parts: (1) Subject database to transmit and accept outside data; (2) Storage, management, backup and maintain of all the raw data; (3) Output and external services of the data; (4) Maintaining the security, integrality and consistency of the data in the system.

The structure of the object-relational database can be divided into three levels: The bottom level contains the commercial relational database management system, user access management applications, and specific management applications of data with user-defined format. The middle level contains the OLEDB based uniform data support interface of attribute data and spatial data. The top level is the various tools and applications for the data cross-access, which contains: data input, data output, data inquiry, file transmitting, user management, database maintaining, database monitor, etc.

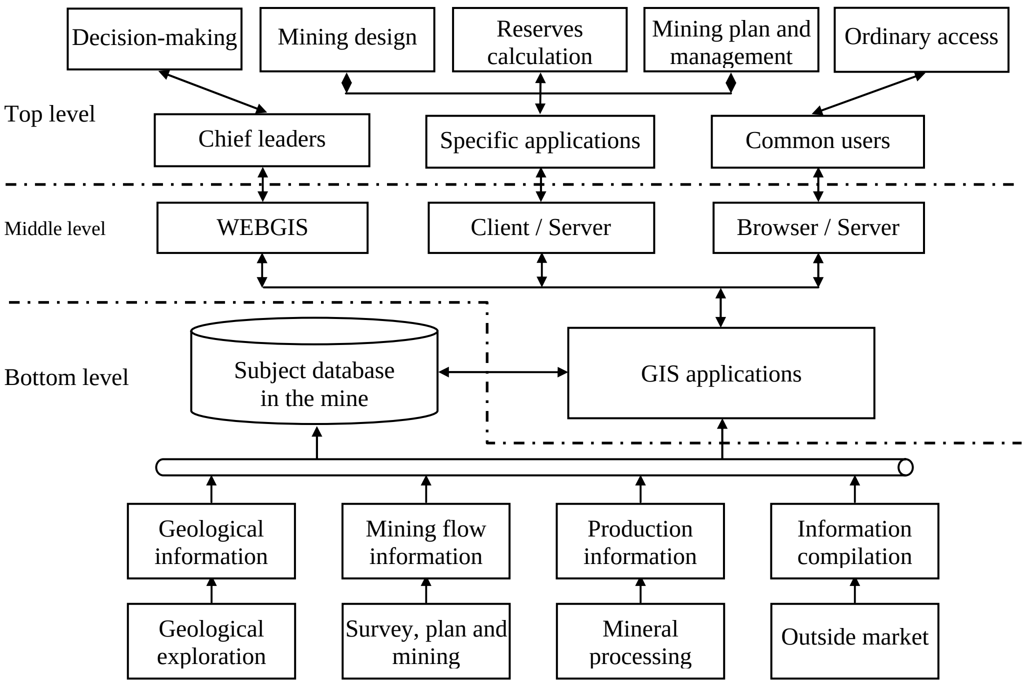

Fig. 2. The logical structure of the geological and mineral resources point-source information system in the mine.

The entire point-source information system is a cascading composite structure based on database and supporting software platform. In such system (Fig. 2), the first level is the data management (bottom level). The second level is the data management, distribution, and processing (middle level), which accepts the information inquiry. The third level is the client browser, processing and application (top level), which is the interface for applications.

Fig. 3 shows us the data infrastructure design in Zijin mining group of China. The group consists of quite a few mines in China and the data sharing and interchanging within the group is charging by the research institute in the headquarters. The infrastructure adopts the theory of point-source database, which contains three steps in the approach: Firstly, carrying out database construction in one key mine as an experimental unit. Secondly, when the standard data mode is set up, building up chief data server in the research institute in the headquarters, meanwhile, generalizing the data mode in other mines of the group. Thirdly, leasing out special network from network service suppliers to form the data infrastructure of the group. Thus ensure the consistency of database structures and data modes within the group.

Fig. 3. The network configuration of data infrastructure in Zijin mining group.

6. Conclusions

At local organizations (subcompanies), the point-source database based system set up the workstation the management and processing of various data, such as survey, geology, geophysics, geochemistry, remote sensing, geoengineering, geohydrology, geoenvironment, and mining flow. It improves the speed and visualized level in data processing, analysis, storage, inquiry. In the network, the point-source database comes to be the standard node in the data infrastructure, and ensure the consistency of data mode of different departments or subcompanies within the group. The point-source database can efficiently realize the unification, scientificalness, real-time, and efficiency of information management in the mine, and ensure the cost-effective in mining enterprise management.

7. References

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